Journal of the Society of Arts.

FRIDAY, MAY 20, 1859.

CONVERSAZIONE.

The Second Conversazione of this Session will be held on Saturday evening, the 28th inst., at the South Kensington Museum, the card for which will admit the member and two ladies, or one gentleman. These cards have been issued.

EXHIBITION OF INVENTIONS.

The Exhibition was opened on Monday, the 25th ult., and will remain open every day until further notice, from 10 a.m. to 4 p.m., and is free to members and their friends. Members by ticket, or by written order, bearing their signature, may admit any number of persons. Members of Institutions in Union with the Society are admitted on showing their cards of membership.

EXAMINATION PRIZE FUND, 1859.

The following are the Donations up to the present date :—

	£	s.
John Ball, Examiner in Book-keeping (2nd donation)	5	5
Harry Chester, Vice-Pres. (2nd donation)	5	0
C. Wentworth Dilke, Vice-Pres., Chairman of Council (4th donation)	10	10
T. Dixon	1	1
Frederick Edwards (annual)	1	1
J. G. Frith, Mem. of Council (2nd donation)	5	5
F. Seymour Haden (annual)	2	2
W. Haldimand	10	10
Edward Highton (annual)	2	2
James Holmes (annual)	1	1
Henry Johnson (2nd donation)	25	0
London Committee of the Oxford Middle Class Examinations	5	5
Charles Ratcliff (annual)	10	10
Dr. Skey	1	1
Rev. Dr. Temple	6	6
A Teacher	5	0
Matthew Uzielli	50	0
Rev. A. Wilson	2	2

OPENING OF GALLERIES OF ART IN THE EVENING.

Since the publication in last week's *Journal* of the letter from the Trustees of the National Gallery in answer to that addressed to them by the Council of the Society of Arts on this subject, the following further reply has been received from that body :—

National Gallery, 17th May, 1859.

Sir,—In reply to the suggestion that the National Pictures should be exhibited to the public in the evenings, as well as by day, I am directed to state that the pictures which are about to be deposited temporarily at South Kensington, being totally distinct from the collection of the South Kensington Museum, will necessarily continue subject to the arrangements which have hitherto been invariably observed at the National Gallery.

I am, Sir,
Your obedient Servant,
R. N. WORNUM,
Secretary, &c.

The Secretary, Society of Arts, Adelphi.

TWENTY-THIRD ORDINARY MEETING.

Wednesday, May 18, 1859.

The Twenty-Third Ordinary Meeting of the One Hundred and Fifth Session was held on Wednesday, the 18th inst., Sir John Rennie, F.R.S., in the chair.

The following candidates were balloted for and duly elected members of the Society :—

Battam, Thomas, Jun.	Hollingshead, J.
Edenborough, S. Bolton	Silver, Hugh Adams
Hancock, Walter	Wood, Vice-Chancellor Sir W. Page
Harman, Thomas	

The following Institutions have been taken into Union since the last announcement :—

Chelsea, Athenæum.
Sheffield, Literary and Scientific Institution.

The Paper read was—

ON THE RELATIVE VALUES OF COKE AND COAL IN LOCOMOTIVE ENGINES.

By Benjamin Fothergill.

Having attended a meeting in the Society's rooms, on 2nd December, 1857, and taken part in the discussion relating to the use of coke and coal in the furnaces of steam-engine boilers, I then undertook to lay before its members the results of a series of experiments which I had made with coke and coal in locomotive engines in corroboration of the truth of my assertions:

First, that coal was decidedly superior to coke in respect to heating power, and consequently more economical;

Second, that a plentiful supply of steam could be generated by the use of coal for working engines at high velocities and for drawing heavy trains;

Third, the capabilities of coal-burning engines for consuming their own smoke; and,

Fourth, the increased durability of fire-boxes and tubes when coal was used.

On that occasion I stated that my experiments had been conducted upon the London and South Western Railway, and were made, at the request of the directors, to ascertain the value of an invention which had been patented by their Locomotive Superintendent, Mr. Joseph Beattie. This contrivance will be readily understood by referring to the drawings on the walls, where the fire box is shown in section, divided transversely into two compartments by an inclined water space mid-feather or diaphragm, and a dependent water space hanging from the roof. Both compartments are arched over with fire tiles at narrow intervals apart. The boiler is constructed with a combustion chamber, extending to about one-half its length, and it has a vertical mid-feather or diaphragm in the centre running parallel with its sides. The other half is supplied with tubes in the ordinary manner. The object of this contrivance is to increase the amount of direct heating surface and to diminish the indirect or tube surface, whilst the combustion chamber affords sufficient space for the introduction of a series of fire tiles, for the purpose of retaining a portion of the

heat given off from the combustion of the gases in the fire box, and for diffusing the unconsumed carbon, as well as effecting a complete mixture of the air with the gases, and thereby producing a mass of flame which is brought in contact with the direct heating surface of the combustion chamber before it enters the tubes, at the same time preventing practically such an escape of smoke from the chimney as could be deemed a nuisance.

The back or first furnace is the most actively worked, the second being intended to carry incandescent fuel. The ash pans are furnished with dampers for the admission of air when necessary; and this is also admitted through the small apertures in the fire doors and through hollow stays in the fire box.

In addition to the mechanical contrivances referred to, Mr. Beattie has another of considerable importance for using a portion of the exhaust steam for heating the feed water before it enters the boiler, and, as I have tried both his contrivances for this desirable object, I need only refer to the one represented on the drawing, which shows the pipes for conveying the water and steam to the tank under the foot-plate of the engine, from which the feed-pumps receive their supply. The water is received on to a perforated plate in this tank, and in its descent comes in contact with and condenses the steam, and thereby becomes heated; the supply of water is regulated by the ball-tap or valve, and the steam is admitted or shut off whenever the engine driver has occasion to supply or shut off the feed-water to the boiler.

In the course of my first series of experiments, I have used the feed-water supplied by Mr. Beattie's apparatus, at a temperature of 196°.

I may here observe that I was anxious to obtain an analysis of the fuel used by the London and South Western Railway Company, and the more so as I found that they manufactured their own coke from "Ramsay's Coking Coal" (Newcastle), which is of a superior quality; and as it was desirable to ascertain, as far as possible, whether the coke or the coals which were supplied to me contained the greatest amount of sulphur, I sent samples of each to Mr. Dugald Campbell, Analytical Chemist to the Brompton Hospital, and he, after a careful examination, furnished me with the following statement, viz.:—

"The samples I received were four in number, and marked as follows:—

No. 1.—Ramsay's coking coal.
No. 2.—Coke.
No. 3.—Llanguathog Merthyr, shipped Swansea, Neath, and Cardiff.
No. 4. Griff coal.

"No. 1.—Ramsay's Coking Coal

is of a jet sparkling appearance, and is broken up without much difficulty by the fingers into rather thick layers, between most of which are thin plates of iron pyrites, which, I may state, is a compound of iron and sulphur, in the proportion of one of the former to two of the latter. When the coal is reduced to a very fine powder—in which state it is required for analysis—its jet black appearance gives place to a considerable brown tint, which indicates it to be of a bituminous character.

"This coal is rather above the usual density of Newcastle coal, being 1,279, water taken as 1,000.

"The analysis in 100 parts is as follows:—

Carbon	85·57
Hydrogen	5·68
Oxygen	3·07
Nitrogen	1·48
Sulphur	1·46
Moisture	0·74
Ash	2·00
	100·00

"The calorific value of a substance is generally estimated in two ways; firstly, by calculating from its ultimate analysis what quantity of water a known weight of the fuel would evaporate from 212° Fah.; and, secondly, by ascertaining how much oxide of lead is capable of being reduced to the metallic state by a known quantity of the fuel.

"These experiments when conducted upon the different specimens of fuel under precisely similar circumstances, which has been the case in this instance, give results extremely useful for comparing the economic value of the fuel. By such means, 1lb. of No. 1 Ramsay's coking coal was found to be capable of evaporating 15·18lb. of water from a temperature of 212° Fah., and 1lb. of reducing 34·99 lbs. of metallic lead from the oxide.

"No. 2.—Coke made from Ramsay's Coking Coal.

"The specimen I received of this substance was a thin column, which, from its appearance, must have occupied a space from the top to the bottom of the coke in the coking furnace. An average sample was selected from this for examination, and the results obtained were as follows:—

"Density of coke 1,055, water being 1,000. The analysis in 100 parts.

Carbon	86·91
Hydrogen	1·32
Oxygen	0·10
Nitrogen	0·80
Sulphur	1·94
Moisture	1·28
Ash	7·65
	100·00

"One pound of this coke is capable of evaporating from 212° Fah. 12·78lb. of water; and 1lb., of reducing from the oxide of lead, 31·35lb. of metallic lead.

"No. 3.—Llanguathog Merthyr.

"This coal has a bright sparkling appearance, resembling to some extent (No. 1) Ramsay's coal; but it is rather more dense, and not so easily broken; when broken however, the layers are not so thick, and between them no iron pyrites are visible, but thin plates of silicate of lime are occasionally noticed.

"Density of coal, 1,333; water 1,000. The analysis in 100 parts.

Carbon	89·16
Hydrogen	4.06
Oxygen	1·65
Nitrogen	1·21
Sulphur	1·39
Moisture	0·67
Ash	1·86
	100·00

"One pound of this coal is capable of evaporating from 212° Fah., 14·74lb. of water, and 1lb. of reducing from the oxide of lead 34·74lb. of metallic lead.

"No. 4.—'Griff' Coal.

"This is a coal of a dull appearance, dense and hard, with a concoidal fracture, different from either of the other two coals.

"Density of coal, 1,341; water, 1,000.

"The analysis in 100 parts.

Carbon	66·21
Hydrogen	4·09
Oxygen	11·07
Nitrogen	1·13
Sulphur	1·01
Moisture	9·23
Ash	7·26
	100·00

"One pound of this coal is capable of evaporating from 212° Fahr. 9·8 lb. of water, and 1 lb. of reducing from the oxide 25·14lb. of metallic lead.

" TABLE OF FOREGOING RESULTS :—

	No. 1. Ramsay's Coking Coal.	No. 2. Coke from Ramsay's Coking Coal.	No. 3. Llan-guathog Merthyr Coal.	No. 4. Griff Coal.
Density	1·279	1·055	1·333	1·311
Carbon	85·57	86·91	89·16	66·21
Hydrogen	5·68	1·32	4·06	4·09
Oxygen	3·07	0·10	1·65	11·07
Nitrogen	1·48	0·80	1·21	1·13
Sulphur	1·46	1·94	1·39	1·01
Moisture	0·74	1·28	0·67	9·23
Ash	2·00	7·65	1·86	7·26
	100·00	100·00	100·00	100·00
Pounds of Water which 1 lb. of Fuel would evaporate from 212° Fahr.	15·18	12·78	14·74	9·8
Pounds of Lead reduced by 1 lb. of Fuel	34·99	31·35	34·74	25·14

" In glancing at the above table, the first thing that arrests the attention is the proportion of sulphur being greater in the coke than in the coal from which it was made, and by nearly half a per cent.

" It appears from my analysis that, although in coking coal there may be a notable loss, in the per centage of carbon, hydrogen, oxygen, and nitrogen, in the coke, yet the sulphur has not only not decreased, but has actually increased in the per centage. I find in the coking oven that not more than one-twelfth of the sulphur goes off from the coal, whilst the loss of the other gases is upwards of one-third of the whole.

" But portions of the coke may be found to contain a very much larger quantity of sulphur than I found in the above specimen, and if I had selected a piece from near the top of the column, instead of taking an average of the whole, I should have found very much more than I did.

" The pieces of coke delivered to me by your assistant, which he told me he had taken from a quantity from the tender of an engine in going down to Southampton, on the 2nd ultimo, gave on an average 5·62 per cent. of sulphur, and some which I selected myself from the coke-heap at the Nine Elms station gave about 5 per cent.

" The next peculiarity to be noticed between the coke and the coal from which it is made is, in the amount of ash being very much higher in the former than in the latter; this is caused by an excess of iron and silica principally, and were it not for the increase of ash there would not be so very much difference in their heating power, &c. I can only account for this increase in these two substances from their being volatilised in the coking-ovens, and entering into the crevices of the fuel from which the gases escape.

" It is common to find large quantities of a hair-like substance adhering to the coke, varying in colour from a light-grey to black; this is silica, with a trace of carbon and iron, and which has been in a state of volatilisation till arrested by coming to a cooler part of the coking-oven, where it has condensed, and is found as I have described it.

" NO. 3.—LLANGUATHOG MERTHYR COAL,

you will observe, is a coal of a very superior quality, and is nearly equal to Ramsay's coking coal in heating power, and has a very little less per centage of sulphur; but No 4, 'Griff' coal, though containing less sulphur than either, does not possess such heating power, which is partly owing to its containing a large per centage of water; this water is expelled when the coal is reduced to a fine powder, and submitted for some time to a temperature of 212° Fahr. The moisture in the other specimens was determined in a similar manner.

" I may state that my experiments were repeated, and great care was bestowed to verify any results which appeared contrary to what should have been expected, such as the larger amount of ash in coke, in comparison to the coal from which it was made, and the larger amount of sulphur in coke than in coal, the general belief being that in the coking of coal most of the sulphur is driven off."

I will now proceed to give a detailed statement as to my mode of procedure to ascertain the quantity of fuel consumed per trip from the Waterloo Station, London, to Southampton and back again, inclusive of the quantity used in getting up steam in the morning, and whilst waiting at Southampton. I personally inspected the weighing of the fuel in the morning, and again at Southampton, and on the return of the engine to Nine Elms I took an account of the coal which remained on the tender, and I had the fire-box cleared out, the hot material cooled and riddled, and the worthless portion separated, and I allowed the value in good coal for the remainder.

I commenced my experimental trips with the coal engine " Ironsides," which had been constructed on Mr, Beattie's patented plans, for burning coal only, and heating the feed-water, and took the 10.15 A.M. mail train from Waterloo to Southampton, and arrived there at 1.5 P.M. We commenced the return journey at 3.0 P.M., and arrived at the Waterloo Station at 5.58 P.M., the engine having performed the trip in the most satisfactory manner, and without any appearance of smoke, except when the steam had to be got up in the morning, or the fires prepared for the return journey.

The result of that day's trip will be seen by referring to the tabulated summary opposite November 15th, where the average consumption of fuel is shown as 16·71lbs. of coal per mile, or when reduced to its coke value equal to 11·14lbs. per mile, with an average load of 12·2 carriages per mile, travelling at an average speed of 31·25 miles per hour.

I have said that the consumption of coal, when reduced to its coke value, was equal to 11·14lbs. per mile; in explanation of my meaning, I beg to state experience has proved that, in order to make one ton of good coke suitable for locomotive engines, 1½ ton of the best coking coal is required, and with some kinds of coking coal, 1½ to 1¾ ton are necessary to produce one ton of coke. It will be evident then, that if the same load can be taken, at the same velocity and under the same circumstances in respect to weather, with equal weights of fuel, say with coal in engines fitted up with Mr. Beattie's patented contrivance, and with coke in the ordinary class of engines, a net saving is effected of one-third, or 33 per cent., in fuel alone, without taking into consideration the incidental saving consequent on the construction of coke ovens, the interest on capital, the cost of their maintenance, and the wages of workmen employed in the manufacture of coke.

From the tabulated summary, it will be seen that I worked the coal engine "Ironsides" for three days with little variation in respect to the quantity of fuel consumed, that little variation arising from the change in the weather. I then selected the coke-burning engine " Vesuvius," one of the ordinary class, and being nearest in dimensions and weight to the "Ironsides," and in good working order, and with it I took a similar train (10.15) to and from Southampton, burning coke only, and I adopted the same course of proceeding as on the former trips, but with a very different result as regards the consumption of fuel; for, on referring to the general summary, it will be seen that the average load was 12·1 carriages, the average speed 30·27 miles per hour, while the average consumption of fuel was 20·62lbs. of coke per mile. On the following day I took the "Express" train with the same engine, but the results were substantially the same as on the previous day with the " mail " train.

Having tried the " Vesuvius," I decided upon taking another coke-burning engine (the " Frome,") which was a similar class engine to the " Vesuvius," in order to ascertain if their was any difference in the results of their working. On referring to the summary of the trip opposite November 22nd, it will be seen that the consumption of fuel was remarkably near that of the " Vesuvius."

I then determined to test the capabilities of another

coal-burning engine, the "Canute," and compare the results of its working the "express" train with that of the "Vesuvius." The load was lighter, averaging 9·3 carriages, but the average speed attained was higher, being 36·76 miles per hour. The consumption of fuel was 16·71 lbs. of coal per mile, the coke value of which is 11·14 lbs. per mile against 20·62 lbs. per mile consumed by the "Vesuvius."

The experiments up to this period showed a decided advantage in the coal-burning engines, so far as regarded economy of fuel, &c., but the results were not conclusive to my mind, inasmuch as the engines had not worked under precisely the same circumstances with respect to weather and uniformity of load and speed. I therefore obtained a sufficient number of carriages to form two trains of equal size and weight, and I had a quantity of materials weighed and placed in each of them equivalent to a load of passengers. The coal-burning engine "Canute" was attached to one of the trains, and the coke-burning engine "Vesuvius" to the other. The weight of the train, including engine and tender, drawn by "Canute," was 170 tons, 8 cwt., and that drawn by "Vesuvius," 167 tons 12 cwt.

The trains left London and Southampton within a few minutes of each other, so that there could be no difference between them in respect to weather, but lest either train should run heavier than the other from extra friction in the axle bearings, I took a second trip on the following day with the engines changed from one train to the other. I registered the particulars of each day's trip separately, but taking the average of the two days' working, the difference in respect to consumption of fuel will be more readily seen.

	Average speed.	Average consumption of fuel in lbs. per mile.	Load.
"Canute"	28·40	Coal 20·36	19 carriages.
"Vesuvius"	27·23	Coke 24·37	19 "

Coal reduced to its coke value 13·57, which shows a clear saving of 10·80lbs. per mile.

I subsequently tested the capabilities of the coal-burning engine "Canute" for making sufficient steam when drawing heavy loads, and as this engine was rather heavier than the coke-burning engine "Vesuvius," I obtained an additional number of carriages, and after they had been weighted I had twenty-eight of them attached to the "Canute," and twenty-two to the "Vesuvius," making the total weight of the "Canute" train 235 tons 13 cwt., and that of the "Vesuvius" train 189 tons 6 cwt. I was very desirous of testing the capabilities of the coal engine "Canute" for drawing a heavy load up the incline from Southampton to Andover (a distance of 22 miles) without the aid of a pilot engine, and for that purpose I added about 20 tons extra weight to its train beyond its proportionate load.

Early in the morning of December 19th, 1855, we proceeded to Southampton with the two trains, but unfortunately the water pipe attached to the lower part of the boiler in the "Canute" engine gave way, and the leakage therefrom became so great soon after we left Southampton that we were obliged to pump into the boiler an extra supply of water to compensate for the loss sustained. A reference to the registered account of the trip on that day will show that while the "Vesuvius" (coke) engine evaporated 7·13 lbs. of water by 1 lb. of fuel, the "Canute" (coal) engine evaporated 9·05 lbs. of water by 1 lb. of fuel. The amount of water, therefore, which passed from the tender of the "Canute" engine was greater by 1·92 or nearly 2 lbs. of water per 1 lb. of fuel than that from the tender of the "Vesuvius," but notwithstanding that mishap, the "Canute" generated sufficient steam to draw the 28 loaded carriages up the incline without any aid whatever.

The firing from the same cause was increased, but the result on the day's work of the two engines was still in favour of the coal-burning engine, as will be seen from the summary, and it is worthy of remark that when the coal is reduced to its coke value, the result is 10·80 lbs. per mile in favour of the coal burning engine "Canute."

I have shown that the saving effected by the coal-burning engines with the ordinary trains was equal on the average to 8·56 lbs. of coke per mile, or 10·80 lbs. of coke per mile when each engine worked under the same circumstances as to weather, &c., with equal loads; now, if the former quantity, viz., 8·56 lbs. per mile be taken, the saving is equal to 1·348 lbs. on each trip, or at the rate of 187¾ tons per engine per annum, at six days work in each week; but if the latter quantity, viz., 10·80 lbs. per mile be taken, the saving is equal to 1·721 lbs. at each trip, or 239½ tons per engine per annum.

The consumption of coke by the coke-burning engine "Vesuvius" during one of the trips referred to was 29½ cwt., which, at 31s. 6d. per ton, was equal to £2 6s. 6d., whereas the consumption of coal-burning engine "Ironsides" during another of the trips was 24¾ cwt., which, at 19s. per ton, was equal to £1 3s. 6d., giving a clear saving on the latter per trip of £1 3s. In my report to the Directors of the London and South Western Railway Company, I stated that if they had seventy engines in steam per day, and each of them was fitted up for burning coal, and all worked under similar circumstances to the "Ironsides," there would be a daily saving to the company of £80 10s., or £483 per week of six days, or £25,116 per annum.

From the result of these interesting and important experiments I trust I have succeeded in demonstrating the truth of the assertions I made at the meeting to which I have referred, namely, that coal can be used more economically in locomotive engines than coke; that by the use of coal sufficient steam can be generated to supply locomotive engines when working at high velocities and when drawing heavy loads; and, in support of my assertion relating to the capability of coal-burning engines, built in accordance with Mr. Beattie's patent, consuming their own smoke, I have to observe that a goodly number of them are at work on different lines of railway, and testimonials of their efficiency have very frequently been given.

There yet remains the question of the durability of the fire boxes and tubes when coal is used instead of coke, and I do not think that I could offer a better proof of the superiority of coal over coke in this respect also, than by quoting a portion of a report which I made on this important subject on the 26th of May, 1858, to the Locomotive Superintendent of the Manchester, Sheffield, and Lincolnshire Railway. The engines there referred to were built in accordance with Mr. Beattie's patent for burning coal and coke:—

"With respect to the durability of the tubes and fire-boxes, when coal is used instead of coke, I consider that question to be settled beyond dispute in favour of the former, inasmuch as it no longer remains a matter of opinion merely, but the result of continuous working with coal and coke demonstrates beyond all doubt that not only is coal superior to coke in respect to heating power, and consequently decidedly more econonomical, but it is less injurious to both the tubes and fire-boxes of locomotive engines; as a proof of this I beg to append a copy of a tabular statement which I had the honour of laying before the directors of the London and South Western Railway in the month of March, 1856, showing the average duration of a set of tubes in their locomotive engines when coke alone was used. At that time as well as in the latter part of 1855, after I had made a series of experiments with coke and coal, I came to the conclusion that the tubes and fire-boxes would sustain less injury by the use of coal than coke, and although one of their coal engines had then run but 51,300 miles and no really appreciable depreciation had taken place in either fire-box or tubes, I saw sufficient to warrant me in concluding that the life of a set of tubes, as well as that of the fire-box, would be considerably prolonged by the use of coal instead of coke. Time has proved that the opinion I then formed was a correct one, inasmuch as I have, up to the present moment, carefully watched the effects produced on the fire-boxes and tubes of the locomotive engines on the London and South-Western Rail-

way; and taking two of their engines which I have examined, where even part coke and part coal have been used up to the commencement of the present month, you will perceive the amazing difference in favour of coal when you compare the results with the tabulated statement copied from my printed Report, dated March 25th, 1856.

Miles Run by the Undermentioned Coke Engines, with One Set of Tubes, on the London and South-Western Railway.

Working Pressure of Steam.	Name of Engine.	Miles run.
100 pounds	Volcano	118,978
100 ,, ...	Stromboli ...	127,855
100 ,, ...	Vulcan.........	128,947
100 ,, ...	Milo...........	104,627
100 ,, ...	Etna	105,985
90 ,, ...	Ruby	101,905
90 ,, ...	Serpent	92,048
80 ,, ...	Medusa	106,590
100 ,, ...	Windsor	99,907
100 ,, ...	Mercury	73,100
80 ,, ...	Fire King ...	102,258
80 ,, ...	Mazeppa	89,059
100 ,, ...	Sussex	99,624
100 ,, ...	Mars............	103,257
100 ,, ...	Comet.........	97,201
80 ,, ...	Hawk	74,955
80 ,, ...	Acheron	87,759
100 ,, ...	Test............	76,182
100 ,, ...	Stour	69,688
100 ,, ...	Rocklia	86,469
100 ,, ...	Avon	78,785
100 ,, ...	Trent	65,634
100 ,, ...	Frome.........	83,108

Average duration of tubes, 94,518 miles.

"From the above table you will perceive the average duration of a set of tubes was 94,518, whilst in the two engines I have referred to, where coal and coke have been used, one of them has run 154,955 miles, and is now carrying 120 pounds pressure of steam, none of the tubes having failed, and they are still in good working condition, and I am unable to say how much longer they will last. The other engine has run 137,676 miles, and I have had two of her tubes sent to my office in Queen's Chambers, Manchester, which you can see at any time.

"I personally paid a visit to the works at Nine Elms and examined these engines; and, bear in mind, that although a portion of the fuel used in these engines is coke, yet the tubes I now refer to have only worn to the extent of three wire guages in thickness; they were ordered and made to No. 13 wire gauge, and are now No. 16 wire gauge.

"No doubt exists in my mind that the principal portion of this amount of reduction in thickness is attributable to the cutting action of the coke, and not to the effect of any deterioration produced by the action of the coal. With regard to the effect on the fire-box of the latter engine, the back, sides, and crown, are $\frac{1}{32}$ of an inch less than their original thickness, namely, $\frac{1}{2}$ an inch; the tube-plate has been reduced $\frac{1}{16}$ of an inch, the original thickness being $\frac{3}{4}$ of an inch. From these facts you will be able to draw your own conclusions—they speak for themselves—for in one case, where coke alone was used, you have an average (taken from the Company's books) of 94,518 miles as the life of a set of tubes, whilst in the other, where coke and coal are used on the same railway, and working similar trains, you have 154,955 miles run in the one case, and 137,676 miles in the other, and the tubes still in good working condition.

"I have given you these facts as a sample of the results when coke and coal are used, because the fuel you are using in your engines is of a similar character; but I am prepared to prove that were your engines constructed to burn coal alone, the fire-boxes and tubes would be protected from the cutting action of the coke, and greater durability, much beyond the mileage I have reported for coke and coal, would be the result. I am not ignorant respecting the argument that some persons have advanced as to coal containing a greater amount of sulphur than coke; this is a fallacy which I have had proved beyond doubt, and therefore I hesitate not to give you a strong opinion in favour of coal, for instead of its proving destructive to fire-boxes, tubes, or smoke-boxes, the result of my observations and experiments proves the contrary."

In further confirmation of the increased durability of the tubes, I beg to state that the mileage of another engine of the same class as the two referred to, and burning a mixture of coke and coal amounts to 181,589 miles, and the tubes are still in good condition, and working at a pressure of 120 pounds to the square inch.

In conclusion I beg to remark, that previously to the year 1853, several attempts had been made by different individuals to introduce coal as a substitute for coke in locomotive engines, but from various causes they did not persevere in developing its true commercial value, and I would take this opportunity of stating that the credit of this important saving in railway expenditure is due to the skill and persevering industry of Mr. Joseph Beattie.

Summary of Experimental Trips made on the London and South Western Railway.

DATE.	Name of Engine.	Description.	Average Time in Hours and Minutes.	Average Speed in Miles per Hour.	Average Feet Consumed in lbs. per Mile.	Coal Reduced to its Coke Value.	Quantity of Water Evaporated per Mile in lbs. for 1 lb. of Fuel	Highest Temperature of Water in Tender during each Trip.	Lead in Number of Carriages.	Weight of Train including Engine and Tender.	REMARKS.
1855.										Tons Cwts.	
Nov. 15.	Ironsides .	Coal.	2·31	31·25	16·71	11·14	8·29	124°	12·2	...	Beautiful, clear, frosty day and calm.
,, 16.	Ditto	Coal.	2·31	30·68	17·24	11·49	6·72	158°	10·6	...	Damp foggy day, rails greasy for 50 miles.
,, 17.	Ditto	Coal.	2·39	29·71	19·02	12·68	7·07	164°	12·1	...	Clear day, with strong side wind in favour of down and against up journey.
,, 19.	Vesuvius .	Coke.	2·36	30·27	20·62	...	7·15	76°	12·1	...	Wet drizzling rain, with light wind on our back.
,, 20.	Ditto	Coke.	2·26	35·23	20·62	...	7·78	74°	12·2	...	Rails rather greasy; wind against down journey.
,, 22.	Frome ...	Coke.	2·27	32·14	20·97	...	7·62	94°	13·3	...	Ditto ditto ditto.
,, 23.	Canute ...	Coal.	2·11	36·76	16·71	11·14	7·35	166°	9·3	...	Fine clear day, with light wind in favour of down journey.
,, 30.	Ditto	Coal.	2·49	27·65	20·51	13·67	8·26	142°	19·0	170 8	Fine frosty day; rails greasy for first 50 miles.
,, 30.	Vesuvius .	Coke.	2·56	26·54	23·82	...	8·21	54°	19·0	167 12	This was the first trip with equal loads.
Dec. 1.	Canute ...	Coal.	2·39	29·16	20·22	13·48	8·07	180°	19·0	170 8	Great difficulty in starting. Rails slippery in consequence of frost and damp fog; wind rather stiff against us.
,, 1.	Vesuvius .	Coke.	2·47	27·92	24·92	...	7·78	54°	19·0	167 12	
,, 19.	Canute ...	Coal.	2·55	26·92	29·80	19·86	9·05	...	28·0	235 13	Frosty, with strong head wind against us.
,, 19.	Vesuvius .	Coke.	3·09	24·71	30·16	...	7·13	36°	22·0	189 6	Water pipe in Canute gave way. Shut off heating apparatus.

DISCUSSION.

The Secretary read the following communication, received from

Mr. D. K. CLARKE, who says—I perfectly agree with Mr. Fothergill in assigning to Mr. Beattie the honourable position of pioneer in the successful practical introduction of coal as a substitute for coke in locomotive engines, as there can be no question that, by his persevering efforts, he first succeeded in fairly arousing public attention to the real magnitude and importance of the economy in working expenses in railways that might be effected by the general use of coal as fuel. I believe that from this source of economy alone an addition of nearly 1 per cent. may be made to the dividends on the original share capital of railways, taking one with the other, with the reduced tear and wear of locomotives so ably pointed out by Mr. Fothergill. I think, however, that the mode adopted in the paper, of illustrating the saving in cost effected by the substitution of coal for coke is open to criticism, and does not place the question on its proper basis. It is true that the quantity of coke manufactured from a given weight of coal weighs only two-thirds of the original coal so consumed, and that 1½ ton of coking coal make only one ton of coke. But in seeking to establish this ratio of three to 2 as the measure of saving, that is, that the cost of fuel is reduced one-third in dispensing with the coking process, it is overlooked that coking coal, as coal, is not the proper fuel for locomotives, and that therefore the calculation of saving should be based, not upon the relative quantities of coking coal and of coke made from it, but upon the relative prices and efficiency of proper locomotive-coal and coke. This ratio is necessarily very variable, as it is affected by cost of transport and other elements. For instance, on one metropolitan line, whilst coking coal costs 12s. 6d. per ton, and the coke made from it costs 18s. 6d., other coal, suitable for locomotive uses, costs as much as 15s. per ton. On another line, whilst the cost of coke is 23s. per ton, the coal suited for locomotives costs 20s. per ton, or only 13 per cent. less. Again, take the North Eastern Railway, at Newcastle, the difference of the cost of coke at from 8s. to 11s., and locomotive coal, at 7s. per ton, is so inconsiderable as to scarcely make it worth while to use coal on that line. Notwithstanding such local approximations in cost, there can be no doubt of the economical importance of the question before the meeting. Again, in the comparison of the coal-burning engines with the coke-burning engines of the South-Western Railway, no allowance has been made for the benefit of heating the feed-water in the former, as against the use of cold water in the latter ; whereas my own experience with Mr. Beattie's engine, the Canute, showed a most material increase in the consumption of coal when the feed-water was not heated. The following were the results I obtained from the engine with hot and cold water respectively :—

	Average train.	Coal consumed per mile.		Temperature of feed-water.
With heated water	11 carriages	17·4 lbs.	...	191 deg.
With cold water...	11 ditto	24·0 lbs.	...	56 deg.

Showing an increase of 6·6 lbs. of coal per mile, by using the feed-water cold, as was done in the coke-burning trials recorded by Mr. Fothergill. The coke value would therefore be 16 lbs. per mile, and not 11 or 12 lbs., as assumed in the paper, for comparison with the coke-burning engines. The large extra consumption of coal, by shutting off the heating apparatus, is no doubt greater in proportion than would be deducible from the known constituent heat of steam and water ; but it is caused also by the less favourable working conditions of the engine involved in the use of cold water. I hope, on another occasion, to bring the results of my own practice in coal-burning without smoke before the Society.

The CHAIRMAN said the paper they had heard was a very interesting one, and reduced itself to this :—Mr. Fothergill proposed to establish that which appeared to be a very simple proposition, namely, that the whole was greater than its part; in other words, that coal which contained all the elements of combustion and locomotive power was more effectual than the same coal when deprived of some of its elements and converted into coke. It was a most important subject, not only to railway companies, but also to the public at large, who must derive great advantages from the enormous saving in the expenditure for fuel, which Mr. Fothergill had pointed out, and his arguments appeared to have great plausibility. He (the Chairman) would now be happy to hear the opinions of gentlemen present, whom he knew to be well acquainted with the subject.

Mr. GRANTHAM had listened with great pleasure to Mr. Fothergill's paper, as treating of a subject of very great importance, not only in a scientific point of view, but also as affecting the dividends upon railway property. He must confess that his friend's paper had a little disappointed him upon one or two points, and if it should be agreed that some matters of importance had been omitted, he would call upon the Society to award a gentle punishment to Mr. Fothergill, by asking him to read a further paper upon the same subject. He would, in the first place, call Mr. Fothergill's attention to what he considered an important omission in his paper, he not having stated whether he employed the hot water apparatus in the coke-burning engines, as well as in those burning coal. Perhaps Mr. Fothergill would be good enough to enlighten them upon that subject. He would also ask him whether he had considered the question of the blast in the coke and coal burning engines, as he was of opinion that a much greater heat would be found in the smoke boxes of the latter than of the former, and less blast would therefore be required. That was an important point. Mr. Fothergill had stated that the wear and tear of the tubes of the boiler was very much less in the coal than in the coke-burning engines. That fully corresponded with his own experience; but there was another element to be considered, viz., the first cost of this particular description of engine. There might be a question whether the first cost of the engine, which appeared to be an expensive one, did more than make up for the difference in the wear and tear under the two systems. He did not say this with a view to depreciate the statements made in the paper, for he was an ardent admirer of the use of coal in locomotives. There was also another very important question—viz., the heat of the gases in the smoke box. He was afraid that railway engineers had overlooked this too much, and he feared also that those who had made experiments upon the subject had made some mistakes. He had lately taken pains to make inquiries of some of the leading engineers as to the heat in the smoke boxes of locomotives, and the answer he got generally was, that experiments had been tried, and that the temperature had been reduced as low as 300 deg. of heat; others had informed him that it was about 400 deg. of heat in the smoke box. A curious experiment had been tried in his own neighbourhood, where a thermometer had been let down into the smoke box, the bulb of the mercury going into the box for some distance, and the scale being in sight of the engineer. When the engine was standing at the station the thermometer recorded 300 degrees, but it had no sooner started than the thermometer fell to 150 degrees. This gave rise to some speculation as to the cause of this wonderful phenomenon, and many theories would, perhaps, have been founded upon it, but the whole was easily explained by the fact that round the thermometer there was a space, so that when the engine was put in motion, and the blast came into operation, the cold air struck upon the bulb of the thermometer, and lowered the temperature of the mercury. He believed the temperature of the fire-box

would be much affected by the use of coal, and he was sorry that Mr. Fothergill had not brought that subject forward as an element in his experiments. Within the last few weeks he had been called upon to try some experiments upon locomotive engines in connexion with a subject which he was happy to see illustrated by some specimens upon the table that evening, which he hoped would come before the the Society at a future time in a more connected form. Referring to these specimens of spiral heat-diffusers, Mr. Grantham went on to explain that the glass tubes shown, represented the tubes of a boiler, and contained a spiral bar of metal. This was the invention in the first instance of Mr. Duncan, a gentleman of considerable scientific attainments, who took out a special patent for it. Their mutual friend, Mr. Charles Wye Williams, whose name was honourably known to the Society, without being aware of these experiments, was making others in the most accurate manner of his own upon the same subject, and on an extensive scale. Mr. Wye Williams's apparatus was also the subject of a patent; and as these patents clashed with each other, and there were points in each which the other party thought desirable to be retained, they amalgamated their interest, and the invention was now known under the designation of Duncan, Gwynne, and C. Wye Williams's heat diffusers. Mr. Grantham proceeded to detail the results of experiments made with the heat diffusers as recorded by Gauntlett's pyrometer. The diffusers were placed in the tubes of the boiler, and he knew from experiment that they reduced the heat in the smoke box prodigiously, probably 200 or 400 degrees. The indication of the pyrometer with the heat diffusers in was 800 deg. in the smoke box, and he believed it would have risen to 1,000 or 1,200 deg. if the heat diffusers had not been in use. He had every reason to suppose that if coke had been used in the engine instead of coal, the heat in the smoke box would have been less. If, therefore, Mr. Beattie's or any other coal-burning engine had this enormous temperature in the smoke box, it was evident that there was room for improvement in that respect, and it was another item in favour of coal if these deductions were correct. He would state in passing that the heat diffusers above alluded to promised very good results, the first trials showing nearly 20 per cent of gain, and one of the practical difficulties in using them, viz., the supposed tendency in the tubes to become closed with ashes, had not taken place. Looking at the title of the paper, he regretted that Mr. Fothergill had confined his observations to one system only, as he was aware that he had an abundant store of information upon the burning of coal under other circumstances. He did not say this to detract in any way from the merits of Mr. Beattie's improvements. That gentleman had courageously faced the question, and was the first to direct public attention to it. He (Mr. Grantham) had, however, great hopes that some simpler means than those introduced by Mr. Beattie would be adopted. For a great many years he (Mr. Grantham) had attended the experiments of Mr. Wye Williams, and had been a party to most of the investigations made by that gentleman upon the combustion of coal, and from the experience thus derived, he was of opinion that the operations so necessary in this matter would be carried on by a simpler engine than that of Mr. Beattie—combining, it might be, many of his contrivances, but doing away with a great deal that was complex.

Mr. JOHN BRAITHWAITE, having been called upon by the Chairman, said that having the intention at some future time to bring forward some views of his own in reference to combustion, he must decline entering fully upon the subject that evening. He had listened with attention to the remarks of the last speaker, and there were several of his views which, in the paper that he hoped to be allowed to bring before the Society at a future period, he should endeavour to controvert. Whether it was a question of using coal or coke, he believed the present arrangement of furnaces and the manner of producing combustion were very far behind what he hoped would ultimately be arrived at. He thought that, ere long, the boilers of engines would be constructed of a different form, so as to produce more efficiently the draft in the furnace, not precisely after the plan which he (Mr. Braithwaite) brought forward in 1829, but such an improvement upon it that the combustion would be steadily carried on, and the gases essential to the generation of steam would be given out without the use of the diffuser to which allusion had been made. This principle had been carried out in the caloric engine, and had been found, so far, successful.

The CHAIRMAN was gratified to hear that it was Mr. Braithwaite's desire to give them the benefits of his practical experience in these matters.

Mr. BRAITHWAITE would be glad to do so, and for that reason he would not then forestall anything he had to say.

Mr. JOHN BETHELL being called upon by the chairman, said he did not feel himself competent to say much upon this point, because the paper was chiefly directed to locomotive engines, of which he had had little or no experience. He might, however, make an observation with reference to the general question as to the comparative merits of coal and coke. He confessed he did not think the paper had sufficiently entered into it. Some years ago it was stated at the scientific institutions, that the coke made from a certain quantity of coal would give the same amount of heat, and evaporate just as much water, as the coal from which it was made. He believed that was a theory which was advocated in that room some years ago, by his friend, Mr. George Lowe. He (Mr. Bethell) confessed he was astonished at that theory, for when they observed the great heat that was generated in converting coal into coke, it seemed very remarkable that the coke should, after being subjected to that process, give as much heat as the coal itself. He had burned many thousand tons of fuel in the stationary engines of his manufactories, and after some consideration of the subject it was clear to him that the difference arose entirely in the mode of burning the fuel. It was possible, no doubt, to construct a furnace which would give coal no advantage over coke. The real point was, the proper construction of the furnace. It was excessively simple to burn coke when operated upon by a strong draft, so as to get all the heat out of the carbon which it contained; but it was not so simple to burn coal, because this involved two operations; they had to burn the gases, which required one mode of treatment, and the carbon, or coke, which required another mode of treatment. He confessed he had not yet seen any plan which, in his opinion, was perfect for carrying out his ideas of burning all the gas and all the carbon. The plan laid before them that evening appeared to him very complicated. In France and Belgium, where they burnt a great deal of coal, as well as a patented fuel which contained more gas than coal, they had a simple apparatus for doing it, and they carried out the process in the locomotive engines without producing so much smoke as he had met with on railways in this country. He would not then describe it in detail, but it was a simple arrangement of the fire-box, which allowed air to pass in over the fire. He had hoped the paper would have gone more into the general question, and not have been confined to one description of locomotive. There were many locomotives as well as fixed boilers working in this country, in which various plans were adopted, by which the gas from coal was more or less burnt, though not always efficiently. With regard to the analyses before them, he confessed he was astonished at them, and he could hardly believe them to be correct. It was easy to take an analysis of the composition of coal, but the ascertaining how much water a certain fuel would evaporate was a different matter, as apparatus specially adapted to the different kinds of fuel was necessary in order

to obtain reliable results. If they were using an apparatus to burn coal which contained the gases as well as the carbon, they must have an apparatus in which the air came over the fire, and if the same apparatus was used for burning coke it would not answer. Hence they found it stated in the table before them that 1lb. of Ramsay's coal evaporated 15lbs. of water, whereas 1lb. of coke evaporated only 12 lbs. of water. He believed if the coke were used with a proper apparatus it would evaporate more. Again, they found it stated that the Merthyr coal, which contained 89 per cent. of carbon and 4 per cent. of hydrogen, or 93 per cent. of heat-giving properties, evaporated only 14 lbs. of water per lb. of coal, whilst Ramsay's coal, which contained only 90 per cent. of heat-giving properties, evaporated 15 lbs. of water. That, to a theoretical man seemed an absurdity, and showed that in all experiments as to using fuel for the evaporation of water, everything depended upon the manner in which the fuel was used. The Welsh coalowners had, for a long time, contended that their coal would evaporate a larger quantity of water than the Newcastle coal; latterly, however, the Newcastle gentlemen had asserted that their coal would evaporate more water than the Welsh coal; but, to his mind, such statements ought to have no weight, unless each description of coal was used with an apparatus especially suited for it. Then came the question, whether the apparatus which was suitable for any particular description of coal could be practically adapted for general use with steam boilers. That was a matter which they all knew to be one of considerable difficulty. They could easily construct a small experimental apparatus, but they might not be able to apply it, when coal was burnt in masses for heating large boilers. He did not think the meeting was in a condition to argue this question upon the data given in the paper before them, or to enter into it in a way that its great importance deserved.

Mr. GEORGE LOWE, F.R.S., said, although he was not a locomotive engineer, yet he had been connected with the combustion of coal and coke in London for the last thirty years. He agreed with Mr. Bethell that there were anomalies in the tables before them, which were most perplexing. Some of those anomalies had been already referred to, and in one instance it was evident that there was some mistake, viz., in the statement that there was more sulphur in coke after it had undergone the carbonising process than in the coal itself. As gas men they knew that when the gas was evolved from the coal a certain amount of lime was wanted to get rid of the sulphur which came out of coal during the process; and therefore he thought there must be some error in the analyses before them. The point, however, to which he most desired to address himself was with reference to a statement which Mr. Bethell had noticed as having been made by him (Mr. Lowe) on the occasion of the reading of a paper upon this subject by Mr. Apsley Pellatt when he had the honour of occupying the chair. On that occasion he begged to state he gave the general opinions of the books—of the schools—rather than his own. They all looked up to Mr. Apsley Pellatt as a tolerably good chemist and a close reasoner, and that gentleman's experiments upon the relative value of coal and coke for the purposes of his immense manufactory had been of the most beautiful and satisfactory kind. Mr. Apsley Pellatt would work one week or a fortnight with coal and the next with coke made from the same amount of coal, and he had shown that in every instance the work in his manufactory was done as well with the coke produced from a ton of coal as with the coal itself. There were eminent French chemists who confirmed Mr. Pellatt's views, which were further confirmed by some experiments made at Philadelphia; and it was to be remarked that whilst Mr. Apsley Pellatt was working upon a large scale, the French chemists on a small scale in a laboratory, and the Americans on another scale, and he (Mr. Lowe) was also making his own experiments, the results of all these trials seemed entirely to coincide. He would now say a word or two upon the best mode of conducting the combustion both of coal and coke. The English locomotive had done great credit to the skill of our engineers, as was proved by the fact that as much as 10lbs. of water was evaporated with 1lb. of coal; and there was every hope that much higher results would eventually be obtained. Some of the experiments recorded by Mr. Fothergill were made as far back as 1855; but the French engineers, during the last two years, had made immense progress in the successful introduction of coal into the locomotive engine. After all, the great thing was how to conduct the combustion so as to make use of all the heat-giving properties contained in 1 lb. of coal. Mr. Bethell had, no doubt, hit the point in stating, that it was absolutely necessary that a certain amount of air should go over the fire, as well as through the furnace to produce the proper combustion of coal. Very little air was wanted to go over the furnace if they used coke, but if they used coal, then a certain amount of atmospheric air must go over the furnace so as to combine with, and promote the combustion of the hydro-carbons and other inflammable matters, which, if they got so far as the chimney, went off in smoke and were lost. The great object was to prevent smoke and produce heat. Many years ago his (Mr. Lowe's) father conducted one of the largest malting establishments in the country, and the whole of the heat in the kilns was produced by the bituminous coal of Derbyshire. All the products of combustion went through the kiln, and if any smoke had been produced, five minutes would have sufficed to destroy a very large quantity of malt. For the last thirty-five years there had not been a furnace erected by him, in any part of the world, from Lima to Calcutta, in which the principle of letting a certain amount of atmospheric air pass over the surface had not been adopted. Mr. Lowe directed attention to a model of a furnace designed by him, in 1828, which had remained in Berlin for many years, and in which this principle was shown. He concluded by expressing a hope that Mr. Fothergill would, at some future time, favour them with a further paper upon this important subject.

Professor JOHN WILSON, F.R.S.E., would refer to the comments of Mr. Bethell, in which that gentleman challenged the correctness of the analyses given in Mr. Fothergill's tables. He apprehended that Mr. Bethell imagined these to be practical results, but he (Professor Wilson) believed them to be merely theoretical calculations, based upon the possible evaporating power of coal depending on the quantity of carbon and hydrogen it contained. In No. 1 of the table, the amount of carbon and hydrogen contained in the coal was 90 per cent., and in No. 3 the amount of those elements was 93 per cent., and yet the combustion of the latter gave a smaller amount of evaporating power than the lesser proportion of carbon and hydrogen in No. 1. If Mr. Bethell would bear in mind the vast difference between the power of hydrogen and the power of carbon to generate heat, he would readily be able to reconcile the difference in the results obtained in the two cases, which depended on the atomic proportions in which these two substances combined with oxygen. He thought, therefore, the surplus of carbon in the second case would be more than sufficient to account for the difference between the quantity of water evaporated by the two qualities of coal respectively. This brought him to a point mentioned in Mr. Clarke's letter, in which that gentleman spoke of the difference between coal which was suitable for locomotive engines and that from which coke was made. He stated that the bituminous coals were not those best suited for these engines. If his (Professor Wilson's) idea was right, as to the value of fuel depending upon the amount of hydro-carbons it contained, then the more highly bituminous the coal was the greater would be its evaporative power. Therefore, if they burnt coal they ought to get

that which contained the largest amount of bituminous matter, in preference to that from Wales known as steam coal. Having defended Mr. Fothergill's analyses so far, he would now begin to challenge them himself. There was one point which struck him as rather curious. He could reconcile the difference in the relative quantities of sulphur in coal and coke, for when, as had been stated, it took 1½ ton of coal to make a ton of coke, it was possible that an extra amount of sulphur might exist in the coke; but he could not understand how coal containing 2 per cent. of ash, could be converted into coke containing 7 per cent. of ash, when only 1½ parts of coal went to make one part of coke. He took great interest in the question of the introduction of coal into the locomotive engine, and he should hail any contrivance that would enable the locomotive to consume coal with the same amount of comfort to the public as they now had with coke.

Mr. BETHELL thought he might have been misunderstood in his remarks in reference to the experiments on the relative heating powers of coal and coke. The point he desired to lay stress upon was, that he could not understand, and he could not believe, that if proper apparatus had been used for burning the coke, the evaporative power would have been so small in comparison with that produced by coal.

Mr. CHARLES GREAVES, on being called upon by the Chairman, said he did not feel himself to be well informed upon the bearing of this question as to locomotives, and the paper being specially applied to locomotives, it was only in reference to the burning of fuel in that manner that it was open to much criticism. For his own part, in comparing the efficiency of coal and coke in stationary boilers, and with every contrivance for husbanding heat, he had found coke had produced greater efficiency than coal. He had tried every method for raising coal to the full efficiency of coke by weight, but he had not been able to do so by any process for the admission of atmospheric air. He had taken part in the discussion of Mr. Apsley Pellatt's previous paper about two years ago, and his further experience confirmed the opinion he then expressed, that the superiority of coke over coal by weight was from 12 to 14 per cent. In point of price, however, coke in London was 60 per cent. dearer than coal; there was, therefore, room for a considerably superiority in efficiency by weight of coke over coal, while still leaving a large economy in money in favour of the latter. There was one point about which he should like to hear a little more, that was as to the theory of the coke cutting the tubes of the boiler, for if that were the case what became of the coke? Did it go up the chimney and blow away as solid coke? This point had yet to be determined.

After some remarks from Mr. DUNCAN in reference to the analyses given in the paper,

Mr. FOTHERGILL, in reply upon the discussion, said he had been entirely misapprehended by one or two gentlemen in reference to the analyses he had given. These analyses had been made in the laboratory of Mr. Dugald Campbell, and were not the result of actual experiment from the use of the fuel in a locomotive engine. With regard to the statement of one or two of his friends that he had not brought the general subject fully before the meeting, he begged to state that these gentlemen had overlooked the object of this paper, which he had brought before the Society in fulfilment of a pledge he had given to communicate the results of experiments in which he was engaged as to the comparative merits of coal and coke as applied to the engine which was the invention of Mr. Beattie. That being the case, it would have been, he considered, quite out of place to have introduced more modern experiments in order to confirm the results obtained at that period. With regard to the question of heating the feed-water referred to by Mr. Clarke in his letter, he would state that when experiments were first made with Mr. Beattie's engine that contrivance was not appended to it. The apparatus then used did not enable them to feed the boiler with hot water at starting, but as they proceeded on the journey the temperature of the water became higher; but in the modern contrivance they could commence the journey with the feed water at a high temperature. With regard to the relative quantities of the fuel, he had stated that 1½ ton of coal had been used to produce 1 ton of coke; in some instances the quantity had been 1¾ ton of coal to produce 1 ton of coke; but in order that there might be no misunderstanding upon that point, he had put the calculation into the money shape, and he had stated what the result was without taking into consideration how much coal it required to produce a ton of coke, but had at once given the cost of working the train, which he thought was the legitimate question to which they should turn their attention. He took the coal furnished at a given price, and also the coke, and then instituted a comparison between the two, not troubling himself about the different classes of coal and coke. He had conducted experiments for the Lancashire and Yorkshire, and the East Lancashire Railway Companies, but there was not time to apply the contrivance for heating the feed-water. With regard to the blast-pipe in Mr. Beattie's engines, they had had to increase the amount of air to soften the blast, for if they had a powerful blast, they then got an over-heated smoke-box. He never knew an instance of that upon the South Western line but once, which was during a heavy wind, where they had a powerful blast, and the whole of the steam was used in passing up the chimney. The remainder of the questions discussed he believed had been satisfactorily answered in the paper itself, and he begged to thank the meeting for the attention with which they had listened to him.

The CHAIRMAN said they had heard a most interesting paper, and discussion upon it. After all that had been said on either side, they must come to the practical question—whether the use of coal or coke was the most economical, as well as the best mode of working a locomotive. He had not gathered that the accuracy of Mr. Fothergill's tables, in respect of the comparative economy of the two systems had been impugned. Experiments with the engines at the same speed, and for the same distances had been tried, and the result was as Mr. Fothergill had stated; and unless any one was prepared to impugn that statement, the case must be considered as so far made out. Mr. D. K. Clarke had made a most important statement. He had said that, supposing Mr. Fothergill's experiments to have been clearly made out, there would be a saving of one per cent. upon the aggregate railway dividends throughout the country, or no less than £300,000 per annum upon the railway capital of 300 millions. He thought the meeting was very much indebted to Mr. Fothergill for his simple, clear, and able statement of a very difficult and interesting question, and he hoped at some future period that gentleman would be induced to give them some further information upon the subject. He was sure the Society would unanimously pass a vote of thanks to Mr. Fothergill for his very interesting paper.

The vote of thanks having been passed,

The Secretary announced that on Wednesday evening next, the 25th inst., a Paper, "On the Application of Definite Proportions and the Conic Sections to Architecture, illustrated chiefly by the Obelisk, with some History of that Feature of Art," by Mr. John Bell, Sculptor, would be read.

UNIFORM MUSICAL DIAPASON.

The following is the article from the *Saturday Review*, alluded to in Mr. Harry Chester's letter on this subject in last week's *Journal*. (See page 453) :—

Very considerable inconvenience has long been felt in the musical world in consequence of the want of a uniform standard by which the pitch of musical instruments, whether used individually or in concert, might be regulated. The tendency in all the most celebrated orchestras to an increased elevation of pitch has been attended by evils which affect the interests of music in no small degree. Composers, instrument-makers, and artists are alike sufferers from this cause, and the great difference existing between the pitches (or diapasons, as they are called) of various countries, or of various musical establishments, is frequently a fertile source of embarrassment in musical transactions. With a view to remedy this acknowledged and growing evil, the French Government some time ago appointed a commission of distinguished men to discuss and collect information upon the whole question; and the result of their labours has lately appeared in the *Moniteur*, in the shape of a very elaborate and interesting report.*

The commission consisted of fourteen members, all of them eminent in the world of music or science, as the following enumeration of their names will show:—Pelletier (Secretary-General in the Ministry of State, President), Halévy, Auber, Berlioz, Despretz (Professor of Physics at the Faculty of Science), Camille Doucet (Ministerial Head of the Theatrical Department), Lissajous (Professor of Physics at the Lycée St. Louis, and Member of the Council of the Society for the Encouragement of Works of National Industry), General Mellinet (Superintendent of the Bands of the Army), Meyerbeer, Monnais (Imperial Commissary at the Lyrical Theatre, and at the Conservatoire), Rossini, and Ambroise Thomas. Any opinions emanating from a body of men so well qualified to judge upon a subject of this nature must necessarily be worthy of attention; and we think, therefore, that a short summary of their report may not be uninteresting to the musical portion of our readers.

The report commences by stating that it is an undoubted fact that the diapason, or pitch, has been steadily rising for at least a hundred years, and that it is now quite a whole tone higher than it was in the middle of the last century. As a proof of this, we have the internal evidence of the scores of Gluck, Monsigny, Grétry, and others, besides the more certain testimony of the organs of the time. Rousseau (*Dictionnaire de la Musique*, article *Ton*), states that the pitch of the opera in his time was lower than that of the chapel, and consequently more than a tone lower than that of the opera of the present day. The first question, then, that naturally presents itself for consideration is, what were the causes which have led to this result? Vocalists cannot fairly be charged with any participation in producing this change. They screamed, it seems, even in those days, without the facilities afforded to them by the operas of Signor Verdi. Besides, it is manifestly never for the interest of the singer that the diapason should be forced up—a circumstance which can only tend to increase his fatigue and make inroads upon his voice. The interests, too, of composers are, for many reasons, opposed to an undue elevation of the pitch. They have, moreover, but little power of influencing an orchestra in this respect. The composer does not fix the diapason—he submits to it. It is, then, says the report, to the instrumentalists and the instrument-makers that this result must be attributed. They are the persons who have evidently a joint interest in raising the diapason of the orchestra. Up to a certain point, the more elevated the pitch the greater the brilliancy and sonority of an instrument.

The numerous inventions and improvements which have been effected in wind-instruments have more than anything induced the unnatural height which the diapason has now reached. A direct confirmation of this is afforded in a particular instance by a letter addressed to the commission, by M. Kittl, the director of the conservatory at Prague, who states that the Emperor Alexander I., upon becoming proprietor of an Austrian regiment, ordered new instruments to be made for the band. The manufacturer, in order to increase the brilliancy of tone, raised the pitch considerably. This having produced the desired effect, the example was followed by other military bands, who all raised their diapason.

With the view of obtaining as much valuable information as possible upon the subject, which is one of universal interest to musical art, the commission wrote to all the most celebrated musical centres in England, Belgium, Holland, Italy, and America. Almost all the answers which they received agree in their estimation of the importance of the subject, and in deprecating the undue height of the diapasons now in use. Some of these communications, coming as they do from composers and conductors of the first eminence, are very interesting. It would, however, occupy more space than we can afford to attempt anything more than a very brief mention of one or two of the most striking. Reissiger writes from Dresden that he hopes all Europe will warmly applaud the establishment of the commission. The great elevation of the pitch, in his opinion, destroys the effect and effaces the character of ancient music—of the masterpieces of Mozart, Gluck, and Beethoven. Ferdinand David, Franz Abt, and Lachner, express with equal decision their aproval of the step which the French Government has taken. Herr Wieprecht, the director of the military music of Prussia, and Dr. Furke each forwarded able papers upon the subject, and manifested a lively sympathy with the objects which the Commission had in view. From several quarters tuning forks, to the number of twenty-five, were received. Of these Messrs. Broadwood sent three, which afford a striking example of the necessity which exists in our own country for some readjustment and assimilation of the pitches now in use. The first is a quarter of a tone lower than that of Paris, and is used exclusively for pianofortes destined to be employed for the accompaniments at vocal concerts. This, it seems, was the pitch used about thirty years ago by the Philharmonic Society. The second, which is higher than the Paris pitch, is that to which Messrs. Broadwood ordinarily tune their instruments, as being most likely in general to be in tune with harmoniums, flutes, &c. It is the diapason of instrumentalists. The third, still higher, is that now used by the Philharmonic Society, and, with one exception—viz., that employed in the band of the Belgian regiment of Guides—is the highest which the Commission received. This latter vibrates nine hundred and eleven times in a second, whereas the No. I. of the Messrs. Broadwood, the lowest of all the tuning forks sent in, gives only eight hundred and sixty-eight vibrations in the same time. This difference is nearly equivalent to a semitone.

With these and various other similar communications before them, the commissioners unanimously came to the conclusion that it was desirable—first, that the diapason should be lowered; and, secondly, that when so lowered, it should be taken as an invariable regulator. The determination of the particular diapason to be adopted naturally presented considerable difficulties, and accordingly led to some diversity of opinion. All agreed that a depression of more than a semitone was neither practicable nor necessary. One member alone advocated a depression of less than a quarter of a tone. He, indeed, proposed that the alteration should at the most extend to half a quarter of a tone—fearing that any greater

* Rapport présenté à son Excellence le Ministre d'Etat par la Commission chargée d'établir en France un Diapason Musical Uniforme.

change, coming suddenly into operation, might act prejudicially upon the trade in musical instruments, which is one of the most successful branches of French industry. It is difficult, however, to see much force in this objection, when we consider the great variety which exists in the diapasons already in use throughout Europe. In a letter addressed to the Minister of State by the principal French instrument-makers, they enlarge upon the embarrassment resulting "from the continually increasing elevation of the diapason, and from the variety of diapasons," and go on to request his Excellency "to put an end to this kind of anarchy, and to render to the musical world a service as important as that rendered to the industrial world by the creation of a uniform system of measures." It is evident from this that the manufacturers themselves do not regard with apprehension the contemplated change of diapason.

Ultimately, a depression of a quarter of a tone was fixed upon. This, it was thought, would afford an appreciable relief to vocalists; and, "without introducing too great a derangement in established habits, would insinuate itself, so to speak, *incognito* into the presence of the public. It would render the execution of the ancient masterpieces more easy; it would lead us back to the diapason employed (in Paris) about thirty years ago—the period of the production of works which have, for the most part, retained their places in the repertory, and which would accordingly be restored to the original condition of their composition and representation. It would also be more likely to be accepted in other countries than the depression of half a tone." In accordance with the recommendations of the commission, an official order has been issued, establishing by law a uniform pitch to be used by all the musical establishments of France which have any connexion with the Government. This "normal diapason" is an A, given by a standard tuning-fork to be preserved at the Conservatoire, which vibrates 870 times in a second. All musical establishments authorised by the state must be provided with a tuning-fork verified and officially stamped as consonant with this standard. These regulations come into force on the 1st of July next for Paris, and on the first of December for the departments.

Such are the energetic steps which the French Government has taken in a question which, in our own country, would probably be thought far too trivial to call for state interference of any kind. It would, moreover, in all probability, be almost impossible for us to effect any analogous reformation in the musical world by means of official legislation, inasmuch as we have—and we regret that it is so—scarcely any musical establishments which are dependent for their support upon the Government, or which can in any way be said to have a national character. Much, however, might be done by private combination. If such men as Professor Bennett, Mr. Costa, Mr. Benedict, Mr. Alfred Mellon, and Messrs. Broadwood could, upon consultation among themselves and with others of our more eminent musicians and instrument-makers, come to some understanding upon this question, and would offer their suggestions to the world, it would not improbably lead to a reform which, as we have before remarked, is even more pressingly called for in our own country than in France, where the movement has originated. It would, at any rate, be satisfactory to know the opinion of the men who, in England, are best qualified to speak authoritatively upon the subject.

ON A NEW METHOD OF MANUFACTURING AMMONIA.

By Alexander Williams, Neath.

The importance of ammonia, and its sister compound, nitric acid, in an agricultural point of view, as forming probably the chief sources whence the nitrogen of plants is obtained, and the high commercial price of compounds containing either of these substances, have led practical chemists to look upon any new method of obtaining them as one of the great desiderata of the day.

The atmosphere, with its water, contains the elements necessary for the formation both of ammonia and nitric acid, and during the passage of electricity both are formed; but, so far as our present knowledge extends, and from a long series of experiments on the subject, I am led to believe that it will be some time ere the Society's premium will be claimed "for the production of ammonia, or nitric acid *from their elements*, by methods which would admit of practical application."

After having been engaged for many years in experiments on this subject, I have arrived at the conclusion that, except under peculiar circumstances, nitrogen and hydrogen in their gaseous, or elementary state, will not combine together in sufficient quantities to be commercially available. To make them unite in any quantity it is necessary that the nitrogen should, in its nascent state, be brought in contact with the hydrogen, when union will take place, but this combination is much more readily effected if both be in their nascent state.

To obtain nascent nitrogen it is of course necessary to decompose one of its compounds, and thus far I had only arrived at the same conclusion as every one else. The object of this paper is to direct attention to a bye-product of one of our most important chemical manufactories, which is exactly adapted for our purpose.

The animal and vegetable kingdoms have been so thoroughly searched by the shoals of manure manufacturers of this and other countries, that the discovery of any new nitrogen compound in these kingdoms seems to be altogether improbable; one is therefore naturally led to the mineral kingdom, and our ideas as naturally become fixed on nitrate of soda as the cheapest source. It has been known for years that nitric acid, or other compounds of nitrogen and oxygen could be converted into ammonia, and therefore the use of a nitrate would present no novelty; but if we can obtain the nascent nitrogen from nitrate of soda as a bye-product, we shall have made a grand step towards facilitating the manufacture of ammonia.

This, I believe, I have accomplished. Of the thousands of tons of nitrate of soda annually imported into this country, I have been told, on good authority, that about half is used in the manufacture of sulphuric acid. It is well known that sulphuric acid is usually manufactured in a large leaden chamber having attached to it a burner where sulphur is kept constantly burning, by which it is converted into sulphurous acid. The great difficulty of the manufacture is to give another atom of oxygen to this sulphurous acid ($S\ O_2$) to convert it into sulphuric acid ($S\ O_3$), and it is for this purpose that the nitrate of soda (cubic nitre) is used, and usually in the following manner:—One or more moveable iron pots are placed in the burner. Into each of these pots is put, as often as required, a few pounds of nitrate of soda, and with it a sufficient quantity of sulphuric acid to decompose it. Sulphate of soda (salt cake) remains in the pot, whilst nitric acid and probably other compounds of nitrogen and oxygen pass with the sulphurous acid into the leaden chamber. The sulphurous acid ($S\ O_2$) gains an additional atom of oxygen from the nitrogen compounds, and becomes converted into sulphuric acid ($S\ O_3$) which, with water afforded by steam jet or otherwise, condenses as a liquid at the bottom of the chamber, whilst a quantity of gas escapes.

Such is a rough sketch of the first part of the process usually adopted for making sulphuric acid or oil of vitriol, and the gas which escapes from the vitriol chamber must now be the subject of our inquiry.

On referring to Dr. Ure, our great authority on manufacturing chemistry, I found that he asserts that, in a properly working chamber nothing but nitrogen gas should escape; in fact, that the whole of the oxygen should be taken up, and that the nitrogen should be reduced to its elementary condition. This, although the generally re-

ceived opinion of the manufacturing chemists of the present day, appeared to me fallacious; as, on considering the affinities, I did not think it probable that sulphurous acid, although it is known to form a compound with nitric oxide ($N\,O_2$), should, under the circumstances occurring in the vitriol chambers, be able to decompose it. Experiments were immediately instituted to ascertain the truth, and they led to the knowledge of the fact that a chemical compound of nitrogen and oxygen was escaping, and not free nitrogen. What particular compound of nitrogen and oxygen it is has not been ascertained, as the fact of its being a *chemical* compound was sufficient for the purpose intended, viz., of applying this waste product for the manufacture of ammonia.

At the commencement of the year 1856, I transferred a portion of the gases escaping from a vitriol chamber to my own laboratory, and there and then succeeded in converting them into ammonia.

This was an important step, but I did not feel satisfied until I had tried the process on the large scale; therefore, in November in the same year, an arrangement was entered into for this purpose with Messrs. Lewis and Pollard, of the Pontardawe Vitriol Works, whose kind assistance in the matter I take this opportunity of acknowledging.

The apparatus fitted up was of the following description:—A furnace was built above the exit tube of one of their vitriol chambers, and a brick gas retort, about 14 inches in diameter, 8 feet long, and open at both ends, was passed through its whole length. This retort was filled with charcoal, and kept at a red heat; the exit tube of the chamber, and a steam-jet to supply the hydrogen, were attached to one end, whilst to the other end was fixed an upright leaden cylinder, filled with coke, and moistened with diluted sulphuric acid. On passing the waste gases and steam through the retort containing red-hot charcoal, both were decomposed, the oxygen of each uniting with the charcoal to form carbonic acid ($C\,O_2$); the nitrogen and hydrogen combining to form ammonia ($N\,H_4\,O$, or, without water, $N\,H_3$); then together, probably forming carbonate of ammonia ($N\,H_4\,O,\,C\,O_2$), which was again decomposed by the diluted sulphuric acid, the sulphate of ammonia being found remaining in solution. This solution was then evaporated, and in July, 1857, I first had the pleasure of obtaining any quantity of crystals of sulphate of ammonia, by this process, from a vitriol chamber in actual work.

It was the intention at that time to have secured the invention by patent, and therefore, when the above comparatively rough result had been obtained, the further prosecution of the experiments to ascertain yield, &c., was not proceeded with, lest the process should become public. Several circumstances have since prevented their renewal. I therefore merely wish to offer the process as it is to those interested in the matter, hoping some one else may apply it more profitably than I have, and feeling sure that—as there seems no reason why it should not be successfully carried out—it will be the means of advancing the "arts, manufactures, and commerce" of this country, by increasing the supply of one of our most valuable fertilizers.

Perhaps it may be thought that the process is only adapted to such gases as escape directly from the chamber, and that, if any of the late improvements as coke cylinders, &c., be used, it cannot be applied; but provided the assertion be correct that sulphurous acid is incapable of reducing compounds of nitrogen and oxygen to their elementary state, then the process will be available after all these improvements have been carried out, and not only to the waste gases, but also, by a slight modification, to any nitrogen compounds that may have been absorbed by the dilute sulphuric acid, and be given off in its evaporation, so that really a very minute portion only of the nitrogen contained in the nitrate of soda need be lost.

With regard to the quantity obtainable by these means. I have not as yet been able to ascertain with certainty the amount of nitrate of soda imported, but, as already stated, it appears probable that about half of the whole quantity arriving in this country is used in the manufacture of oil of vitriol, or sulphuric acid. Now every thousand tons of this cubic nitre, allowing 10 per cent. for impurities would, if the whole of its nitrogen were converted into chloride of ammonia ($N\,H_4\,O$), yield about 565 tons of this substance, which, at £30 per ton, would be worth nearly £17,000, and there are doubtless many thousands of tons of nitrate of soda used by the vitriol makers of this country. Although these figures give, of course, no approximation to the practical yield likely to be afforded by this process, yet they enable us to form a very good idea of the enormous amount of valuable material daily wasted. The process suggested, or some modification of it, may render this waste unnecessary, and thus save the pocket of the manufacturer, and at the same time benefit the public.

ON TIMBER FOR SHIPBUILDING.

The following has been received from the Editor of the *Mechanics' Magazine*:—

From the Paper read before the Society of Arts last week, by Mr. Leonard Wray, it appears that the aggregate tonnage (register tonnage, we presume) of the merchant shipping of the United Kingdom was last year 4,325,242 tons; and that of the Royal Navy is certainly not less than 1,000,000 tons more. When we consider that a very large proportion of these vessels are built entirely of wood, and that in twenty years at the farthest these magnificent fleets will have fallen into decay and disappeared, we may well view with interest any attempt to point out the means of increasing the durability of the materials of which they are composed, or obtaining fresh supplies for their constant reconstruction. In addition to the demands made for timber for these purposes, it appears, from an estimate which enters with considerable minuteness into detail, that ten times as much is required for the construction and repair of buildings, implements of husbandry, machinery, canals, bridges, docks, &c.

The proportion of this vast amount of timber material which could by any possibility be grown on our own soil is very small. It was found in 1816, when the demand was more limited and our stock of timber much greater than now, that the cost of timber imported was equal to the value of that grown on the soil; and since this time the deficiency in the home supply has been constantly increasing. We have seen ships standing week after week, and month after month, in our Royal Dockyards, while the purveyors were out in the forests endeavouring to find suitable timber, not only for stems and stern posts, and other principal portions of the frame, but even for the catheads from which the anchors were to hang; and any one may see by a visit to our dockyards with what difficulty the frames of ships now on the Government slips are obtained, and how greatly the amount of work on them is increased by the choking and patching to which the builders have to resort. But we are beginning to be reconciled to this state of things, and to look forward with some degree of complacency to the time when our little island must cease altogether to supply her hearts of oak to furnish homes for her seamen. The bare possibily of such a catastrophe was viewed by our forefathers with horror. We find Henry VIII. passing stringent laws for the preservation of timber, "perceiving and right well knowing the great decay of timber and wood universally within the realm of England." By Elizabeth it was enacted that if any idle person cut or spoiled any wood or underwood, pales, or trees standing, and could not pay the satisfaction required, they were to be whipped. Receivers of such wood, knowing it to be so, incurred the same punishment. The 15th of Charles II., cap. 2, is an Act to render that of Elizabeth more effective; and it enacts further punishment, because the destruction of wood

tends to destroy the commonwealth. It is therein declared that the officers of justice may apprehend even on suspicion of having carried, or in any way conveyed any burden or bundle of wood of any kind, underwood, poles, young trees, bark, or bast of any tree, gate, stile, post, rail, hedgerow wood, broom, or furze. For the first offence, on conviction, to be fined at the discretion of the justice, not exceeding ten pounds; or be sent to the house of correction for any time not exceeding one month; or be whipped. For the second offence the offender was to sent to the house of correction for one month; for the third he was to be deemed an incorrigible rogue. In Scotland it was enacted, in the reign of James I., that every heritor worth one thousand pounds of yearly valued rent, was to enclose four acres of land yearly, at least, and plant the same about with trees of oak, elm, ash, plane, willow, or other timber, at three yards' distance; and that all other heritors were to enclose and plant for the space of ten years in proportion to their yearly rental. Such enclosed lands were to be free from all taxes whatever, or quartering of horses, for nineteen years. Any persons destroying timber, not being their own property, were to pay £20 for each tree, or work six weeks for the person injured for their meat and drink only. Similar laws were passed for Ireland in the reign of William III., besides which it was required that 260,600 trees should be planted in the kingdom under the direction of the parish officers. And by George III. it was enacted for Ireland that any person who should have in his possession any timber tree, or any kind of wood, pole, stick, &c., and could not give a satisfactory account of how he became possessed of the same, or should pick up branches or shrubs of trees having the leaves on them, in any church, chapel, &c., holly, bay, yew, or laurustinus, and should be convicted on oath, should pay a fine not exceeding £5, or be imprisoned not exceeding six months.

In our own times we sometimes hear enthusiasts proposing to compel railway companies to plant oak trees along the lines, and to take other active means for staving off the threatened calamity; but people seem generally prepared to accept it with resignation. One cause of this probably is, that the comparative cheapness of foreign timber has brought it into very general use, and another that iron has taken the place of wood so largely. This latter cause holds with regard to ship-building timber, not only on account of the large present consumption of iron, but from our faith in its powers, and in the vastness of our store, should we be driven to its nearly exclusive use. Mr. Wray has, however, done well in the very interesting paper which will be found in another part of this number, in bringing under the notice of ship-builders numerous valuable woods of which no use has hitherto been made. In addition to those given by him, we believe there is excellent timber, perfectly accessible, on the Atlantic seaboard of Brazil. There is in particular the *Secupira preta*, the growth of which is very crooked. Its weight is said to be from forty-eight to fifty-nine lbs. per cubic foot, *i.e.*, slightly greater than that of English oak; the grain is curly, and not liable to split with fastening. It is used by the Brazilian Government in the construction of their vessels, especially in the curved parts of the frames. There is a frigate belonging to that government, called the Prince, now in use as a sheer hulk in the harbour of Rio de Janeiro, which was built of this wood forty years ago, and is reported to be in good preservation. The *Secupira preta* can be obtained in abundance at Alagoas, a place near Pernambuco, which is a seaport and a mail station. There is another very crooked and useful wood, called *Pao d'arco*, or arch wood, weighing fifty-five and a half lbs. to the foot, and growing at Bahia, also on the sea-coast; and another, *Canella preta*, still lighter—about fifty and a half lbs. to the foot—but equally durable, and grown on the southern portions of their seaboard. When we consider the cost of English oak—as much as 9s. per cubic foot of the largest sizes—and its great scarcity, involving serious delays in the construction of ships, and much costly and clumsy patching, we think it high time that the Government took steps towards introducing some foreign timber for the frames of our ships of war. In the merchant service—as may be seen from Mr. Wray's paper—several kinds of foreign timber are admitted on equal terms with English oak. In the Government service it is not so. If we except Polish and Italian larches, and Pitch-pine, which are occasionally admitted in small quantities, the frames of all ships built in the home yards are of English or Italian oak. We do not believe there is the least necessity for this—but that on the contrary, there are many and unanswerable reasons for discontinuing the use of oak timber of home growth, at least in the *frames* of ships, altogether. The feeling is, however, so strong in favour of English oak, that merchant builders still employ it largely, though in the majority of cases they pay dearly for it—for the timber which they can afford to use is small, and, to a great extent, spring-felled and unseasoned, and therefore subject to early and rapid decay.

It was our intention, had space permitted, to go into the question of the preservation of timber. We know something of the specifics which have been received into favour at different periods of our naval history, and we quite dissent from Mr. Wray's statement, that there are "simple, well-known remedies" for the prevention of dry-rot. That he is right, however, in predicting that dry-rot will make swift havoc in the newly-converted steam-ships we think probable, and we purpose taking an early opportunity for considering the question. In the meantime, if Mr. Wray, or any of our readers have any well-authenticated experiments on the preservation of the frames of ships by the application of antidotes to dry and wet-rot, we shall be very glad to consider them, and to lay them before our readers.

Home Correspondence.

IRON SHIPS OF WAR.

SIR,—On reading Mr. Wray's letter on the above subject, I find that in the remarks which I made at the meeting of your Society on the 6th inst., I negligently substituted the words "shot" for shell," and "shot-proof" for "shell-proof." I very much regret this error, as it has put Mr. Wray to the trouble of using arguments which would not otherwise have been called for. I would here repeat, what I said at your Society in December last, viz., that "the attempt to build ships which shall be proof to solid shot—at least to wrought-iron solid shot—is an altogether illusory one."

I shall not presume to follow Mr. Wray in his discussion of the general qualities of iron-coated ships. I will merely say that very destructive shells *are* now used in naval warfare, and I know of nothing to prevent the adoption of others still more destructive; and further—with regard to the French shell-proof ships—I think it unwise to trust to capturing them by boarders; and this opinion is shared, I know, by many experienced naval men.

Apologising for thus troubling you, and thanking Mr. Wray for his polite attention to this matter,

I am, &c.

E. J. REED.

166, Fleet-street, London, May 13, 1858.

WATER GAS.

SIR,—Under the above heading I notice an article in last week's number of the *Journal of the Society of Arts*, which gives a history of what has been and is being done in this mode of producing light.

A long list of honoured names is given of men who have attempted to produce illuminating gas by the de-

composition of water—most of whom have effected this object by passing water or steam through incandescent coke or charcoal, and afterwards carbonizing the resultant hydrogen or carbonic oxide with the rich gas produced either from resin, oil, or cannel, for without this the hydrogen gas so obtained would have no illuminating power, and be only fit for heating purposes.

Unfortunately, I can speak from experience, for I purchased the right of one of the persons mentioned (Webster) to erect gas-works, and I erected several, some eight years ago, in this neighbourhood (but not at St. Ives, as the article states), all of which were complete failures, and the conclusion to which I have long since come is, that coal alone is the cheapest material from which to produce gas for illuminating purposes.

It is true that water may be had for nothing, yet the cost of decomposition and carbonizing the gas obtained therefrom, together with the increased wear and tear, make up a total considerably in excess of that which is necessary to obtain gas of a high illuminating power from coal.

But as these remarks apply only to the process of producing gas where decomposition of water, and carbonizing the products obtained, are done separately, it may be said that the process of M. Gillard, which the article describes, supersedes the necessity of carbonization, and that, therefore, his is a perfected system, and one which will supplant coal gas, because hydrogen alone is made to produce a light of considerable power. I propose then to examine his method, and to show what he has done in the places which he has lighted.

It may be premised that artificial light is produced by the incandescence of solid matter, held in suspension in an inflammable gas, and there may either be too little or too much of this solid carbon; if the former—there is but little light; if the latter, the heating power of the hydrogen is not sufficient to convert the whole of it into luminous particles, so they only become charred, and thus form charcoal or soot.

Now M. Gillard produces luminosity by the incandescence of platinum wire, as his gas does not contain any solid matter, and therefore he adopts this expedient; but I am at a loss to know how M. Gillard claims this as his invention, for I find in a paper read before the Royal Society in 1817, by Sir Humphrey Davy, that he gives a description of a method by which light may be produced with mixtures of coal-gas and air, or with fire-damp (which is light carburetted hydrogen), and he gives drawings of his application. The following is an extract of his description:—"J is a small cage, made of wire of platinum, of 1-70th or 1-80th of an inch in thickness, for giving light in inflammable media," so that I think to Sir H. Davy is due the merit of being the first to apply platinum as a light-giving agent, in inflammable gases not possessing any such property.

With regard to the super-heating process described in the *Journal*, one of Webster's plans was to pass the steam through an iron box, perforated with minute holes, placed at the end of the retort, before it came in contact with either coke or charcoal, and this was adopted in the works which I erected.

I notice that the city of Narbonne is mentioned as being one lighted by the Gillard or Davy system, and that M. Gillard is under contract to light 500 public lamps for three years.

I am informed that the only portion of Gillard's plan still retained at Narbonne, is the application of the platinum cage, and that this mode of producing hydrogen has been supplanted by that of another person—his being considered a failure. My authority for the assertion is the *Journal de l'Eclairage au Gaz*, published at Paris, and if any one wish for a full report on "Le Gaz à l'Eau à Narbonne," I would refer him to an article thus headed in the above journal of the 5th February, 1858, the substance of which is this—that to produce 800 cubic metres of water gas at Narbonne costs 154 francs 47 centimes, while the same quantity of coal gas could be produced for 107f. 61c.; and the editor then truly enough says—"If the lighting power of the water-gas would compensate for the difference in the cost between it and coal gas, we could understand why it should be preferred, but precisely the contrary is the case."

I believe it is a well understood fact that to produce the same amount of light by water gas and platinum as from coal gas, double the amount of the former has to be used, so that it is indeed difficult to discover where the advantage of using this gas can be when, in addition, it costs more than coal gas in the first instance; but this is not the only disadvantage it has; the heat produced is very great, and there must of necessity be a considerable deposition of water by condensation on the coldest portions of rooms, when the gas is used by the union of atmospheric oxygen (substituted for that which it lost when the water was passed through the incandescent charcoal) with the hydrogen. Again, if the platinum becomes in the slightest degree cooled, the illuminating power must be diminished, as it is the intensity of its heat which gives the light.

I believe Palma, in the island of Majorca, has been lighted by M. Gillard since Narbonne, and that the whole process has been abandoned in favour of coal gas.

I will only add that, as a gas engineer, I would be among the first to adopt any system which would give a better and cheaper light than that which I can get from coal, whether it were made from liquid or solid—but so long as ordinary Newcastle coal keeps under 50s. per ton, there is not, in my opinion, any substance which can at all enter into successful competition with it.

I am, &c.,
GEO. BOWER.

St. Neot's, Huntingdonshire, 9th May, 1859.

FREE LIBRARIES AND MECHANICS' INSTITUTIONS.

It may be interesting to those readers of the *Journal of the Society of Arts* who value such institutions, to know that a very handsome building has been raised and devoted to the purposes of a Free Public Library (under the Libraries Act) at Lichfield, within the present month. Lord Lichfield presided, and Lord Hatherton and others assisted, at the opening of it. It is well-supported by the Corporation funds as well as by the rate.

I observe a question raised in the *Journal* as to the interference of Free Libraries with Mechanics' Institutions. I am not aware that any results detrimental to Mechanics' Institutions have arisen at Liverpool, Manchester, and other places where libraries have been founded under the Act. I should be disposed to think that a wider opening of the market of literature would (as in matters of trade) eventually do such general good, as to benefit even special Institutions. I am, &c.,

WM. EWART.

Broadleas, Devizes, May 15.

ORIGIN OF THE ELECTRIC TELEGRAPH.

SIR,—In last week's number of the *Journal* there is a notice of Dr. Hamel's communication to the Russian Academy of Sciences, relating to the first telegraph worked by galvanic electricity, which appears to have been constructed in 1809.

It may be interesting to direct attention to a much earlier use of vitreous electricity for the communication of signals to a distance. This will be found in "A letter to C. Mortimer, M.D., Sec. R.S., containing several experiments concerning Electricity, by Mr. Stephen Gray." This is dated, Feb. 8th, 1731, and was published in the *Philosophical Transactions* for 1731, pp. 18-44.

From this it appears that, in August, 1730, Gray suspended an insulated silk line on 15 pairs of poles, and electricity, developed by friction on glass, placed near one

end of the line, caused brass leaf to move at the other, through a length of 886 feet of silk. Another letter from Gray (p. 228) shows he had found that water could convey the electric "effluvium" (as it was termed) in the same manner as silk.

Attention has also been called by Mr. F. Tolhausen, of Paris, to a recent number of *La Presse*, in which the Abbé Barthelemy is said to have suggested an electric telegraph in his well-known work "Voyage du Jeune Anacharsis," which appeared in 1788.

I cannot yet find the exact page of this work for reference, but the passage may be translated as follows:—"It is said that with two clocks (*pendules*, not *horloges*,) of which the hands are similarly magnetised, if we move one of these hands the other would at once turn in the same direction, so that if 12 o'clock were to be sounded on one, the same hour would be sounded on the other. Suppose we could so improve artificial magnets that their power could communicate itself from here to Paris, you would have one magnet and we another. In place of hours, we should have on a dial the letters of the alphabet. Every day, at a given time, we should turn our pointer, and M. Viart read off thus:—'Good day, my dear girl.' That is what grandmama would say. As for me, when my turn comes I will say almost the same. You will perceive that one might still further facilitate the operation, for the first movement of the needle could sound a bell, which would announce that the oracle is going to speak. This idea pleases me amazingly. It would degrade such an invention very much to apply it to getting information in war and politics, but it would be a very pleasant means of communication between friends."

The writer in *La Presse* says we must expect next to find the railway locomotive explained in some ancient Sanscrit manuscript.

I am &c., J. MACGREGOR.

Temple, May 16.

To Correspondents.

In the last number of the *Journal*, in the article:—"The Origin of the Electric Telegraph," p. 453, col. 2, line 16, where it is mentioned that Baron Larrey presented Soemmerring's Telegraph to the National Institute of France on the "4th of December," read "5th of December."

MEETINGS FOR THE ENSUING WEEK.

MON. ......Royal Geographical Anniversary, 1 P.M., when the Gold Medals will be awarded to Captains Burton and Palliser by the President, Sir R. S. Murchison, who will then deliver his address on the Progress of Geography. The dinner will take place at the Freemason's, at 7 P.M.

TUES. ......Linnæan, 1 P.M. Anniversary
Royal Inst., 3. Professor John Morris, "On Geological Science."
Civil Engineers, 8. "On the Manufacture of Malleable Iron and Steel," by Mr. H. Bessemer.
Medical and Chirurg., 8½.
Zoological, 9.

WED. ......Royal Soc. Literature, 4½.
Society of Arts, 8. Mr. John Bell, "On the Application of Definite Proportions and the Conic Sections in Architecture; illustrated chiefly by the obelisk, with some History of that feature of Art."
Archæological Assoc., 8½.

THURS .....Royal Inst., 3. Mr. Austen H. Layard, "On the Seven Periods of Art."
Philosophical Club, 5½.
Numismatic, 7.
Antiquaries, 8.
Philological, 8. Anniversary.
Royal, 8½.

FRI. ......Royal Inst., 8½. Mr. Wm. Pengelly, "On the Ossiferous Caverns and Fissures in Devonshire."

SAT.........Royal Inst., 3. Mr. J. P. Lacaita, "On Modern Italian Literature."
Royal Botanic, 3¾.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

PAR. No.

Delivered on 14th April, 1859.

107. Bills—Vexatious Indictments.
109. „ Manslaughter (as amended by the Lords).

Delivered on 15th April, 1859.

202. Army (Mortality, &c., at Trinidad)—Return.
207. Lunatic Poor (Ireland) Bill—Minutes of Proceedings of the Select Committee.
143. East India (Lands in Enam)—Return.
108. Bills—Clearance Inwards and Lien for Freight.
110. „ Court of Probate, &c. (Acquisition of Site) (as amended by the Select Committee.)

Medical Charities (Ireland)—7th Annual Report of the Commissioners.

PATENT LAW AMENDMENT ACT.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, May* 13, 1859.]

Dated 30th March, 1859.

790. W. Brown, Bolton-le-Moors, Lancashire—Imp. in manufacturing clog soles, and in the machinery employed therein.

Dated 2nd April, 1859.

834. T. Williams, Aberdaron, Caernarvon, and J. H. Fuller, 70, Hatton-garden—Imp. in screw stocks and dies.

Dated 4th April, 1859.

338. C. F. Kirkman, Argyll-street, Regent-street—Imp. in the manufacture of cocoa-nut fibre yarn and matting.

Dated 5th April, 1859.

848. A. Shanks, 6, Robert-street, Adelphi, Westminster—Certain imp. in machinery for forging and stamping metals.
856. T. Scott, Dundee—Imp. in preparing, treating, or manufacturing fibrous materials, and in the apparatus employed therein.

Dated 9th April, 1859.

886. T. Spencer, 192, Euston-road, Euston-square—Imp. in the economical treatment of refuse or waste matter containing sulphur.

Dated 11th April, 1859.

898. B. Baugh, Bradford-street, Birmingham—Certain improved arrangements for working fly presses by steam, water, or other power.
900. W. Schofield, 13, Thomas-street, Stamford-street, Blackfriars-road—An improved effervescing lemonade.

Dated 13th April, 1859.

926. R. Coleman, Chelmsford—Imp. in agricultural implements.
930. J. A. Coffey, 4, Providence row, Finsbury—Imp. in apparatus for heating liquids.

Dated 14th April, 1859.

934. J. Gillett, Upper Brailes, Warwickshire—An improved mill used for grinding, crushing, and reducing bones and other mineral and vegetable substances.
936. T. Bird, Manchester—Imp. in the application and use of a certain natural product or products in the manufacture of pickers for looms, drawing rollers for spinning machinery, cop tubes, and for steps and bushes generally where lubrication is required.
938. J. Beattie, Lawn place, South Lambeth—Imp. in the means of preventing locomotive engines and carriages in motion on railways leaving or running off the rails.
940. W. Barnes and S. Pickering, 127, Brick-lane, Spitalfields, and J. Roberts, William-street, Limehouse—Imp. in retarding and stopping railway locomotives and trains.
942. W. Sinnock, Brompton—Imp. in submarine and subterranean electric telegraph cables, and in machinery for the manufacture thereof.
944. L. J. Higham, New York, U.S.—Imp. in billiard tables.

Dated 15th April, 1859.

948. J. Chapman, Wolverhampton—An imp. or imps. in the manufacture of angle iron.
950. R. Boot, Hill-street, Surrey—Imp. in treating sheep or other pelts, so as to give them the appearance of rough calf.

Dated 16th April, 1859.

952. H. Barrow, Birmingham—A new or improved fastening for fastening trunks, boxes, and articles of dress, and for such other purposes as the same is or may be applicable to.
954. J. Glasgow and S. Hand, Manchester—An improved variable circular motion applicable to slotting, shaping, and planing machines, or similar purposes.
956. W. Clark, 53, Chancery-lane—Imp. in apparatus for separating metals from their ores and other matters. (A com.)
958. J. Hamilton, 8, Exchange-square, Glasgow—Imp. in apparatus for regulating prime movers driven by water.
960. H. Harrison, Blackburn, Lancashire—Certain imp. in looms for weaving.
962. H. H. Vivian, M.P., Swansea—Imp. in smelting copper.
964. G. B. Cornish, New York, U.S.—Imp. applicable to fog horns.
966. J. Moule, Seabright-place, Hackney-road—A new compound liquid for illuminating purposes.

Dated 18th April, 1859.

968. R. Warry, Chatham—Imp. in breech-loading ordnance and its projectiles.

970. G. Porter, London—Imp. in valves or cocks.
972. J. Seaman, Linslade, Buckinghamshire—Imp. in agricultural implements for working or cultivating the soil.
974. J. C. Wilson, Wood-street, London—A reversible shawl cloak.
978. J. Morton and S. H. Morton, Sheffield—Imp. in hearth-plates or ash-pans.
980. G. Coller, Harlow, Essex—An improved mowing machine.
982. W. Parsons, Pontar-Tawe, near Swansea—Imp. in preparing sheet iron and other metal sheets for japanners and other uses.

Dated 19th April, 1859.

986. C. Batty, Manchester—An improved means or apparatus for effecting in tantaneous communication on railways between passengers and officials.
990. J. W. Matthews, High-street, Poplar—An imp. in the manufacture of hats, and other coverings for the head.

Dated 20th April, 1859.

992. Q. Beck, Belfast—Imp. in stoves. (A com.)
994. J. M. Johnson and E. Johnson, Castle-street, Holborn—Imp. in the production of ornamental surfaces suitable for advertisement tablets, plates for shop fronts, and for other uses.
996. H. Rawson, Leicester—Imp. in machinery for combing wool and other fibres.

Dated 21st April, 1859.

1000. E. Cottam, Pimlico—Imp. in apparatus employed for cutting or sawing metals and other substances.
1002. J. Napier, Partick, near Glasgow—Imp. in producing figures or representations upon glass.
1004. J. Davies, Tetbury, Gloucestershire—A new or improved apparatus for ringing door bells, and a bolt to be used with the same apparatus, and for other purposes to which the said bolt is or may be applicable.
1006. R. A. Brooman, 166, Fleet-street—Imp. in knitting frames. (A com.)
1008. E. Clark, New York—Imp. in sewing machinery. (A com.)
1010. S. Truss, Darlington, Durham—Imp. in the construction of pipes, and in the mode of joining the same.

Dated 23rd April, 1859.

1014. C. Mansel, Plymouth—A folding travelling case.
1016. J. Armstrong, Sunderland—Imp. in drying and preserving timber.
1018. J. Angus, Glasgow—Imp. in saddles.
1020. P. L. M. Debain, Paris—Improved means for transmitting motive power to ships, pumps, and other arrangements by which the displacement of fluids is effectuated.
1022. P. L. M. Debain, Paris—Imp. in making heat subservient for producing motive power.
1024. R. A. Brooman, 166, Fleet-street—An improvement in the manufacture of woollen cloth. (A com.)
1026. W. Moxon, Parliament-street, Westminster, and J. J. Bennett, Homer-terrace, Victoria-park, Middlesex—Improved apparatus for raising or lifting and lowering heavy bodies.

Dated 25th April, 1859.

1028. W. Stevenson, Johnstone, Renfrew, N.B.—Imp. in spinning, doubling, and manufacturing cotton and other fibrous materials.
1030. J. Higgin, Manchester—Imp. in treating madder, and plants of the same family, and preparations therefrom.
1032. J. Owen and H. Duckworth, Blackburn—Imp. in machinery or apparatus for leasing yarns.
1034. T. Buckham, Gloucester—An imp. in railway switches.
1036. A. W. Gadesden, 56, Leman-street, Goodman's-fields—Imp. in producing solutions of sugar.
1038. W. E. Newton, 66, Chancery-lane—Imp. in sewing machines. (A com.)
1040. W. Warne, J. A. Fanshawe, J. A. Jaques, and T. Galpin, Tottenham—Improved compounds applicable for packing the joints of steam or other pipes, which compounds are also applicable for packing or lining parts of machinery in general, or parts of ships, bridges, tanks, or railways.

Dated 26th April, 1859.

1042. T. Holt, Lower-place, and J. Brown, Oxford-street, Well Field, Rochdale—Imp. in apparatus, or an improved apparatus, for heating water for the supply of steam boilers, which improvements or apparatus are also applicable in some cases for the prevention of incrustation in steam boilers.
1046. R. Main, Birkenhead—Imp. in wheels for carriages.
1048. R. A. Brooman, 166, Fleet-street—Imp. in vulcanizing and colouring caoutchouc, and in the preparation of caoutchouc paints and colours. (A com.)
1050. J. H. Johnson, 47, Lincoln's-inn-fields—Imp. in machinery or apparatus for combing wool and other fibrous substances. (A com.)

Dated 27th April, 1859.

1052. J. M. Ciroux, Brussels—Imp. in lamp glasses and shades, applicable to gas burners, light-houses, and railway signals.
1054. J. Hyde, Hollingworth, near Mottram, Chester—Certain imp. in steam boilers.
1058. R. J. Laing, Haggerstone, Middlesex—Imp. in wet gas meters.
1060. J. Holroyd, Leeds—Imp. in machinery used for finishing woollen and other cloths.
1062. Sir T. T. Grant, K.C.B., 20, Chester-terrace, Regent's-park—Imp. in ships' cooking apparatus.

Dated 28th April, 1859.

1066. R. Jones, New Kent-road, Surrey—An improved safety lamp.
1068. N. Libotte, 33, Boulevard St. Martin, Paris—A steam brake for mines, which may also be worked by hand.
1072. J. Wheat, Hinckley, Leicestershire—Certain imp. in drilling machines employed for agricultural purposes.
1074. A. Boyle, Birmingham—Imp. in the manufacture of certain parts of umbrellas and parasols.

Dated 29th April, 1859.

1078. H. Bosshard, Paris—An improved mechanism for obtaining and imparting motive power.
1080. S. de Cazenave, 189, Regent-street—An improved lubricating compound.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

1158. J. Luis, 1B, Welbeck-street, Cavendish-square—A self-regulating horse machine. (A com.)—9th May, 1859.
1161. G. G. Bussey, 485, New Oxford-street—An improved contrivance for carrying cartridges and to facilitate using them. (A com.)—9th May, 1859.

WEEKLY LIST OF PATENTS SEALED.

[*From Gazette, May 13th*, 1859.]

May 12th.

2547. J. Courage and F. Bennett.
2548. J. Taylor.
2551. L. Petre.
2552. I. Livermore.
2557. M. Pullan.
2558. J. A. Hopkinson.
2562. G. Davies.
2568. J. G. Bunting.
2569. J. Brennand.
2571. J. C. Boisneau.
2572. A. I. H. Parent.
2573. J. Samuel.
2575. C. J. C. Perry.
2587. J. Robertson.
2641. D. Evans.
2649. F. A. Theroulde.
2669. J. S. Nibbs.
2702. G. B. Sander.
2723. D. Evans and G. Jones.
2736. R. H. Bow.
2752. J. Lewis.
2779. J. B. A. Monnier.
18. I. Wood.
86. R. Hawthorn and W. Hawthorn.
137. J. Montgomery.
205. W. E. Newton.
435. J. J. Russell.
437. J. Seguin.
568. W. Score.
577. C. R. Mead.
615. J. S. Russell.
630. A. V. Newton.
642. A. Tylor.
705. A. V. Newton.
729. Sir P. Fairbairn and R. Newton.

[*From Gazette, May 17th*, 1859.]

May 14th.

2564. W. G. Armstrong.
2583. C. F. Vasserot.
2584. J. H. Tuck.
2586. E. Welch.
2589. E. Mellor.
2591. J. Brennand.
2592. R. A. Brooman.
2598. S. Riley.
2601. Sir C. T. Bright.
2603. H. Stott.
2608. E. T. Archer.
2612. W. S. Hayward.
2616. W. Hancock.
2618. H. H. Henson.
2619. W. Ramscar & J. G. Scott.
2620. E. A. Pontifex.
2621. H. Bailey.
2622. W. Clark.
2627. A. J. Thorman.
2654. W. Ralston.
2655. W. H. Dawes.
2730. A. E. C. Scheidel.
2764. G. E. Noone.
2773. L. W. Fletcher.
2944. E. Fellows.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

[*From Gazette, May 13th*, 1859.]

May 9th.

1105. R. A. Brooman.
1124. H. Tucker.
1162. W. Henderson.
1255. C. Cowper.

May 10th.

1206. A. Allan and T. Hunt.
1246. R. A. Whytlaw and A Mitchell, jun.
1270. L. D. Owen.

May 11th.

1185. J. Wilkes, T. Wilkes, and G. Wilkes.
1201. A. H. Dufresne.
928. U. Scott.

[*From Gazette, May 17th*, 1859.]

May 12th.

1175. R. Knight.

May 13th.

1138. U. Scott.
1150. J. Leck and A. Miller.
1152. H. Greaves.

May 14th.

1254. W. Hulse.

LIST OF DESIGNS FOR ARTICLES OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietors' Name.	Address.
4169	April 29.	Latch Lock	Garton and Jarvis	Exeter.
4170	May 4.	Cottam's Saddle and Harness Airing and Drying Horse	Cottam and Company	2, Winsley-street, Oxford-street, W.
4171	„ 7.	An Artificial Breast	Brigg and Millikin	9, St. Thomas's-street, Borough, S.E.